

Neuro-Fuzzy Networks for Pattern Classification and Rule Extraction

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1. Introduction

In this paper, an experimental evaluation of the neuro-fuzzy models NEFCLASS and FuNN is conducted in real world pattern recognition applications. The models are investigated with respect to classification performance and the number of rules generated and compared to the traditional MLP network trained with backpropagation.

The models NEFCLASS and FuNN are examined in benchmarking problems from the Proben1[3] database and in a large-scale credit card screening problem. A comparison is established with an MLP network and the results obtained show some potential advantages of the neuro-fuzzy classifiers over the MLP particularly with respect to the ability of the neuro-fuzzy models to generate a knowledge base of rules.

2. Neuro-Fuzzy Networks

A neuro-fuzzy network can be defined as a fuzzy system trained with some algorithm derived from the neural network theory. The integration of neural networks and fuzzy systems aims at the generation of a more robust, efficient and easily interpretable system where the advantages of each model are kept and their possible disadvantages are removed. Some neural network models such as the MLP. [1,3] have been successfully applied to the training of neuro-fuzzy networks. The *NEFCLASS* model proposed by Nauck and Klawonn [2] is based on a three-layer *feedforward* neural network[2] and the *FuNN* (*Fuzzy Neural Network*) proposed by Kasabov [1] is a five-layer *feedforward* neural network. Both networks use modified versions of the *backpropagation* algorithm [1,2] to adjust the membership functions (activation functions) and connection weights of the processing units.

3. Experimental Investigation

In order to carry out an extensive investigation of the neuro-fuzzy networks considered in this work, the set of benchmarking problems of *credit card approval* (*card*), *diabetes*, and *breast cancer* extracted from the Proben1 database where applied[3]. A more complex, large-scale, real world problem of credit card analysis was also employed in order evaluate the performance of the models with respect to classification rate and the automatic rule extraction.. The results obtained showed in Table 3.1 show a superior

performance of the neuro-fuzzy models when compared to the MLP results (most cases) reported in the Proben1 paper and also when compared to the experiments conducted independently in this work with the MLP network. The capacity of the neuro-fuzzy models to extract understandable rules was also investigated. In *NEFCLASS*, the rule base generated as a result of the learning process show a reduced number of rules in comparison with the FuNN.

Database	Models	Classification Error %
Cancer	MLP (<i>Proben1</i>)	5,75
	<i>NEFCLASS</i>	1,72
	<i>FuNN</i>	1,15
Diabetes	MLP (<i>Proben1</i>)	23.44
	<i>NEFCLASS</i>	23,28
	<i>FuNN</i>	21,76
Credit	MLP (<i>Proben1</i>)	14,42
	<i>FuNN</i>	10.47
Credit Large-scale credit	MLP	4.5 (good payers) 36.88 (bad payers)
	<i>FuNN</i>	2.67 (good payers) 55.63 (bad payers)

Table 3.1: Test set results

4. Conclusions

The results obtained with the neuro-fuzzy networks investigated were similar to those achieved by MLP networks in the problem examined. In fact, in most cases the correct classification rates in the neuro-fuzzy models were even superior. The ability of these models to perform rule extraction as opposed to the MLP make them attractive for real-world pattern recognition applications.

References

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